Voyager Bulletin

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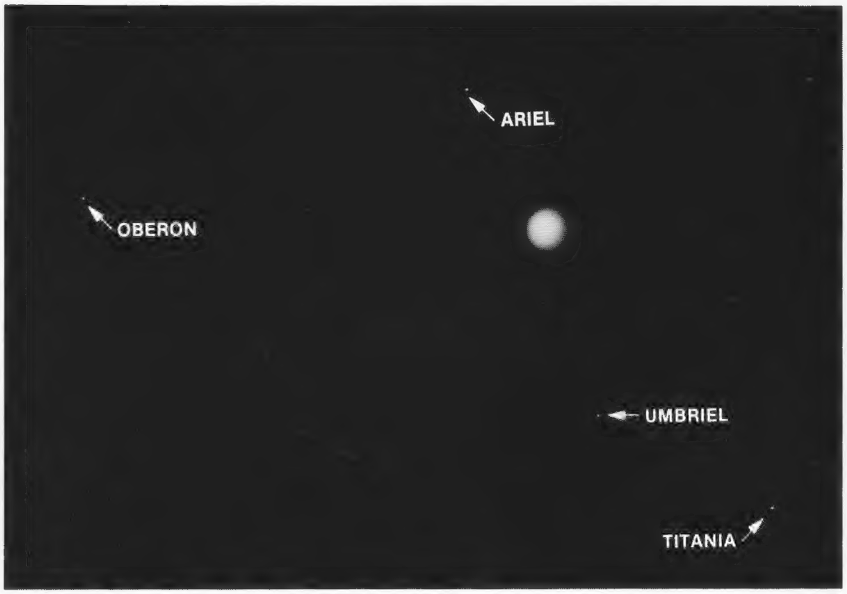
Near Encounter Test

Last week, the Voyager flight team conducted a full dress rehearsal called near encounter test (NET) for Uranus, a final validation of the most complex portion of the near encounter activities to take place in late January. NET exercised the spacecraft, the flight team, and the Deep Space Network. The only thing missing was the Uranian system.

While there are many specific objectives for NET, they can be grouped into four general categories: 1) to verify the spacecraft's execution of the most complex part of the near encounter sequence, about ten hours worth; 2) to confirm radio science readiness—the ability of ground support to acquire and monitor the data; 3) to test the ability of the flight team to meet the timelines for generating and uplinking the late sequence updates; and 4) to simulate the frequency changes that affect the ability to command the spacecraft.



Uranus and four of its moons are seen in this Voyager 2 image taken July 15, 1985 at a distance of 247 million km. Satellite images from a long-exposure frame have been superimposed on the Uranus image and enhanced in brightness to make this composite.

"Some people say the purpose of near encounter test is to test the spacecraft, but I think it is more to test ground operations: are the people and equipment ready to handle what the spacecraft produces," explained Doug Griffith, manager of Voyager's flight operations office.

Near Encounter Load

"NET included all of the 'movable block'," explained Ellis Miner, assistant project scientist. "This movable block is a computer sequence containing the most complex part of the encounter period."

Included in this time frame will be closest approach to all five known Uranian satellites—Miranda, Ariel, Umbriel, Titania, and Oberon—in quick succession, as well as closest approach to the planet, crossing the ring plane, and Earth and Sun occultations (as the spacecraft passes behind the planet, radio communications with Earth and light from the Sun are temporarily blocked).

All of Voyager 2's instruments were operating and making observations during NET. The scan platform was slewed to point its instruments, but of course images were of deep space rather than Uranian objects. These images will be used to validate the pointing.

Tests of image motion compensation maneuvers were included in NET. At Uranus, where light levels are approximately 400 times dimmer than at Earth, camera apertures must be open longer to gather more light. Combined with the motion of both the spacecraft and the target body, this would result in lower resolution images. Merely slewing the scan platform to track the body (similar to panning the motion of a racer with your own handheld camera) would not be effective since, for one thing, the platform slews in steps rather than one smooth motion. The solution is to use the spacecraft's attitude control system in a new way. The spacecraft is normally stabilized by celestial references, but it can also be stabilized by internal gyros, using the attitude control thrusters to compensate for drift. To compensate for image motion, the spacecraft will be put under control of the gyros at a proper drift rate during the image exposure time. Using this technique, the resolution of Miranda images, for example, will be improved by a factor of 50.

Radio Science

Radio science experiments at Uranus require precise timing and coordination among many elements of the project and NASA's Deep Space Network (DSN).

The highest value science data will be returned to Earth while the spacecraft is "over" the Australian Deep Space Communications Complex, where one 64-meter antenna and two 34-meter antennas will be arrayed with the 64-meter Parkes Radio Observatory antenna (located about 320 kilometers to the northwest) to form one large aperture to capture the spacecraft's signal. From Earth's southern hemisphere, the spacecraft will appear high on the horizon for about 12 hours at a time, allowing good data capture for long periods. NET was conducted while the spacecraft was over Australia.

One of the most critical radio science experiments will occur when the spacecraft passes behind the planet. As the radio signal passes through the planet's atmosphere, it will be bent slightly in the direction of the center of the planet. At any given time during the occultation, only one spot in the atmosphere will bend the radio beam precisely in the direction of the Earth. The spacecraft will track this critical spot by performing a series of pitch and yaw turns. The pointing must be exact. At Uranus, the limb tracking experiment will provide valuable information on the planet's atmosphere. For five hours, the spacecraft will use its internal gyros for spacecraft pointing, rather than celestial references.

Changes in the radio signal will also provide information on the rings as they pass between the Earth, the Sun, and the spacecraft. The spacecraft will use its S-band radio signal (which has a wavelength of 13 cm) at high power to study the atmosphere and its X-band signal (with a wavelength of 3.6 cm) at high power to study the ring particles. Since the output of the spacecraft's radioisotope thermoelectric generators (RTG's) is not sufficient to run both frequencies at high power at the same time, the X-band must switch from high to low power while the S-band high-power mode is being used for atmospheric measurements. Following the atmospheric occultation experiment, the X-band and S-band will be commanded back to their normal power levels of high and low, respectively.

NET included tests of these critical radio science events.

Late Stored Updates

"We have designed the 'movable block' so we can shift the timing of its execution by up to twelve minutes," explained Miner. "This is because the position and velocity of the spacecraft relative to the planet, its rings, and the satellites will not be known precisely enough until shortly before closest approach, when we can see the effects of gravity on the spacecraft's trajectory. Using radiometric and optical navigation data, the flight team will compute this positional data and transmit new instructions to the spacecraft just hours before the block begins. In addition, within the movable block, the timing of the radio science limb tracking maneuver can be shifted by up to 72 seconds."

"Although we had designed a movable block for Titan observations at Saturn, we were able to update that sequence *before* it was transmitted to the spacecraft. These instructions will be transmitted after the sequence is already resident in the spacecraft's computers," Miner concluded.

NET tested the flight team's ability to complete the late stored update activity, using the latest navigational data.

Best Lock Frequency

One of the operational quirks of Voyager 2 stems from the loss, in April 1978, of both the prime radio receiver and a tracking loop capacitor on the backup radio receiver. The failed capacitor makes it impossible for the spacecraft to track a changing radio signal. Worse yet, the "rest" frequency is very sensitive to temperature changes in the receiver.

The Voyager flight team has developed techniques for predicting the rest frequency as a function of time, translating that to a predicted transmit frequency as a function of time and Deep Space Station, and transmitting at the appropriate frequency under computer control. To further complicate matters, some spacecraft events, such as the X-band and S-band power switching mentioned above, switching other major power users on or off, or changing the spacecraft's attitude with respect to the Sun, have serious thermal effects on the receiver frequency. To combat this, periods from 24 to 72 hours are allowed after such events to permit the spacecraft's receiver frequency to stabilize before routine command transmissions are resumed.

"We are scheduled to uplink the post encounter computer sequences soon after completion of the near encounter activities," said Griffith, "and our ability to load these commands depends on our ability to track any frequency changes that occur during near encounter due to radiation, thermal effects, or doppler shifts."

A key effort during NET was to simulate as closely as possible the frequency changes that affect the ability to command the spacecraft. Only changes due to spacecraft power switching can be simulated; those due to radiation or doppler shift cannot.

Results

"The 'quick-look' assessment immediately following NET showed that the test objectives were met," said project manager Dick Laeser last Friday. "Moreover, the test served its purpose in flushing out some problems in the details. The timeline for the late stored updates is very tight and we encountered several problems in holding to the schedule. We may make some minor modifications to it before encounter. In addition, there were some procedural and ground system problems that will have to be fixed."

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